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Elimination of Wastes in Pasta Manufacturing using Value Stream Mapping Techniques: A Case Study of Golden Pasta Company, Lagos.

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***Abstract*— Manufacturing industries in Nigeria have been faced with fierce competition, higher production cost and ever-increasing customer's demand for a whole decade. In order to survive in today's fiercely competitive market, achieve customer's satisfaction at a lower cost, many manufacturing outfits started thinking on the best way to eliminates wastes through the lean methodology. Therefore since the presence of these wastes are very prominent in pasta manufacturing plants which have resulted to higher production costs and insatiable customer's requirements, eliminating wastes in the pasta manufacturing processes cannot be over-emphasized hence the choice of pasta. This work focuses on the analysis of the current state mapping of a particular company (Golden Pasta Company) to identify wastes, present problem solving techniques to eliminate the identified wastes and then proposes a future state mapping to the company with expected potential cost savings. The manufacturing operations of Fava Long Goods 3 (FLG3) of Golden Pasta Company was carefully understudied. Data collected from the company, Enterprise Resource Planning system (ERP) and shop floor including feedback from the customers were evaluated. The results of the evaluation shows production lead time was massively reduced from 1.43 days to 5.04 hours with a 85.3% waste reduction. A practical approach of implementing the value stream mapping, using Microsoft Visio 2016 software was suggested. A potential cost savings of N42, 188,880 yearly would be realized after the waste elimination. This was shown in the financial balanced sheets approved by the financial director of the Golden Pasta Company.**

Keywords—Value Stream Mapping, Lean Methodology, Enterprise Resource Planning, Wastes.

1. INTRODUCTION

Pasta manufacturing plants in Nigeria sprang up in the early 2004 (Princess and Justin**,** 2014) with Golden Pasta Company, a subsidiary a Flour Mills of Nigeria leading the pasta food group among others such as Dangote Pasta Company. Honeywell Pasta, and lately Power Pasta Company in 2014. The Pasta industries in Nigeria have been faced with fierce competition, higher production cost and ever-increasing customer's demand for a whole decade. Many pasta manufacturing industries have adopted cut-throat management such as organization restructuring, assets availability, material planning and mass production to maximize profits and boost productivity which yielded verifiable results in output but unfortunately most of these ideas boomeranged leading to excessive non-valued activities along the entire production lines and distrusted consumer's satisfactions.

In order to survive in today's fiercely competitive market, achieve customer's satisfaction at a lower cost, many manufacturing outfits started thinking on the best way to eliminates wastes through the lean methodology. Lean manufacturing philosophy was practiced in Japan many years ago around with associated cost benefits that includes reduced inventory, reduction in production lead time, and increased customer satisfaction (Womack and Jones, 1994, 2003).

The core idea about lean methodology is maximizing customer value while minimizing waste. A lean organization understands customer value and focuses its key processes to continuously increase it.

In every manufacturing processes there are processes that are essential but are non-value adding while others are non-essential yet non- value addition. Eliminating these non-value added processes are best done by learning to see through the processes from its input stage to the finished output, and to the customers.

Therefore since the presence of these wastes are very prominence in pasta manufacturing plants which have resulted to higher production costs and insatiable customer's requirements, eliminating wastes in the pasta manufacturing processes cannot be over-emphasized. Waste elimination should be a priority for any manufacturing industries that is aiming to beat stiff competition, achieved customers' satisfaction at lower production cost because 90% of manufacturing activities are directly or indirectly non-value addition (David and Hashe , 2016).

The extensive study has shown that over the years various lean techniques such as Total Productive Maintenance (TPM), Quality Matrix, 5S, Work Study etc. adopted and implemented have shown significant rise in productivity but the results were achieved with longer lead time and higher amount of scraps.

Value Stream Mapping is a lean technique that was first developed in 1990 by the Toyota Production System (TPS) in the automobile industry. Value Stream Mapping has been deployed to other automobile industries and construction companies with results showing successful identification and elimination of non-value adding activities termed 'wastes'. The techniques of value stream mapping in achieving lean

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goal is so unique that virtually all wastes can be identified and eliminated. This value mapping techniques focuses on creating value for the products and services. Once the wastes are identified and eliminated, the tremendous results leads to lower production lead time, improved customer's satisfaction at a much lower production costs.

A Value stream map is a pictorial representation of all processes, material flow, information and complete data of what occur in the manufacturing operations right from the input stage to the point of customer's delivery of the final output.

The purpose of value stream mapping is to provide visibility of the entire process and minimize wastes that prevents smooth, continuous flow of products and information throughout the value stream. A value stream includes both value-added and non-value added elements that occur to a given product from its inception through delivery to the customer. Mapping out the activities in the manufacturing process with cycle times, down times, in-process inventory, material moves, information flow paths, helps to visualize the current state of the process activities and guides towards the future desired state. The process usually includes the physical mapping of the current while also focusing on where you get to, or the "future state" map, which can serve as a foundation for other lean improvements strategies.

The research work was done, by applying Value Stream Mapping techniques (VSM) towards achieving quick delivery of customer's request within a short time by identifying the wastes from inception of raw material to the point of delivery to customers and eliminate the root cause of these wastes for the overall lean improvement objective of the manufacturing company. Although this thesis has been limited to a pasta Production Company, available literature shows that VSM can be applied to all other sectors of manufacturing with necessary adjustments. By eliminating wastes throughout the entire manufacturing operations, real value will be added to products and services to the overall delight of the customers at lower production cost.

Thus, the aim of this paper is in three folds: (1) develop a current state map of the Fava Long Goods 3 (FLG3) spaghetti production line and identify non-value and value added activities along the production processes for Golden Pasta Company, Lagos; (2) model a problem solving techniques to eliminate wastes; (3) propose a future map and state the cost benefits of the lean implementation. The paper is organized as follows: Section 2 describes the development of the current state, model adopted to eliminate wastes and future state value stream maps of Fava Long Goods 3 (FLG3) spaghetti production line; section 3 presents the results; section 4 discusses the results; section 5 gives the conclusion.

2. METHODOLOGY

The Golden Pasta Company (GPC) production operations runs two shifts per day, 1 hour break internal inclusive (12 hours per shift) and seven days a week production schedules. The planning department raised monthly transfer orders for semolina supply to GPC using Enterprise Resource Planning, ERP electronic platform. Raw material semolina supplied via bulk truck by Flour Mills of Nigeria Plc. (FMN) is first weighed on arrival at the GPC factory. An average of 20 trucks are normally raised and supplied per week. Each bulk truck weight 30 tons of semolina. The trucks are positioned at the nearest discharge point where three Quality tests (moisture analysis, granulation, and high base test) are performed before discharging into the silo bins. The semolina discharged into silo bins are transported to the feeder (hopper) in the FLG3 production line via pneumatic automation system. The semolina discharging process into the flour doser is controlled automatically by a call sensor.

The next production stage is the mixing of semolina and water at the pre-mixer to form dough. The dough is subjected to a pressure of between 100-120bar through the die to form the desire pasta shape. The strands of spaghetti formed are conveyed into the sticks at the spreader unit. The sticks-carrying pasta are transported into the pre-dryer unit through the intermediate chain.

At the pre-dryer unit, initial amount of moisture is removed from the pasta strands through thermoregulation process using circulating pumps and ventilation fans driven by electric motors. This involves the removal of initial water added at early stage of the process via: conduction, diffusion, evaporation. Pasta stands are heated to specific temperatures (conduction).

The Pasta moves to the dryer through a chain drive to floor 1 ($74\text{-}75\ ^{0}c$), floor 2($74\text{-}75\ ^{0}c$), floor3 ($82\text{-}84\ ^{0}c$), floor 4($82\text{-}84\ ^{0}c$) at a moisture content of floor 1-2(13.5%), floor 3-4(12%).

At the end of the drying process, the pasta still has quite an elevated temperature temperature. But from this moment on, the temperature of the product has to start decreasing in order to reach values (parameters) close to the ambient ones. Also the humidity in the air must correspond to the technological characteristics of this phase. The dried pasta is trnansported through into the humidifier unit in order to stabilize the product once the drying phases are terminated.bHere moisture of the product is increased by 0.5% to attain 12.5% total moisture.The pasta moves through the chain drive to the cooler at a temperature of ($28\text{-}30\ ^{0}c$), In this phase, the product is cooled until ambient temperature is reached. The cooled product which has attained the desired stability is transported by roller chain drive to the storage silos, where the material would be called for packaging. The next stage of the production process is the stripper unit, spaghetti strands arranged on sticks are moved by chain and accumulator to the stripper cutters where pasta strands are stripped off from the sticks cut into sizes and the plain sticks removed back to the spreader unit through the lowerator and chains. The sized spaghetti measuring 21cm each are transported by means of elevators and conveyors to the packing machines where the finished products are packed into 500g sachets. Inspection and counting of products are done at the transit zones by the warehouse supervisor before moving the products to the warehouse for storage.

Products demand is considered in the customer service department, a sub-unit of the sales department when a customer walks-in or calls to place an order while on queue. The total number of customer's orders received in a month is sent to the logistics department while annual sales forecast is forwarded to production planning department by sales team.

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Finished goods are not produced by customers 'demand but by annual sales forecast.

Once monthly orders have been received by the logistics department, each customer's request containing total quantity of spaghetti in cartons, name of the customer and truck number are converted to daily customer's gate pass based on arrangement in queue. The gate passes are forwarded to warehouse team. Once the warehouse had enough stock to meet the customer's request, customer will position his/her truck for loading. After loading usually done by manual labourers (loaders) and checked by factory operatives (checkers), the truck owners will proceed to the security gate to weigh the products and dispatch the factory after thorough checks, and inspection at the security gate. The warehouse will check if the stock and total quantity available can meet the customer's request. The GPC is currently meeting customers' demand of 6500 cartons per day. The current challenge is customers' requests are met at longer production lead time and re-occurring production bottlenecks which will be discussed in details in the consequence chapters.

2.1 Current state Map

Before the development of the current state map, an interactive forum was held with top management executives of the Golden Pasta Company (GPC) for 3 days. The interactive forum which took place at the company's conference room was a 5 hour per day session where lean training, objectives and problems affecting the bottom-line were discussed. The forum was attended by the General Manager/Director (GMD) who was the executive sponsor, Financial Director, Quality Control Manager, Production Manager, Head of Sales, and Human Resources Business Partner (HRBP) along with the Researcher (Project Facilitator). At the end of the training session, Top management executives gave full support for the commencement of the project, objectives and timeline of the project were signed off with the researcher.

The following steps were used to develop the current state map,

1. Select a product family

The first step in value stream mapping implementation is to select the product family by looking at the entire product brands in Golden Pasta in terms of customers' sales, and also determine the pilot production line in terms of output and number of breakdowns.

a. Customers sales by product

In this research paper, records of product-sales matrix for the past 4 years, derived from company's ERP were analyzed to determine the product with the highest customer's value. The data below were obtained from the company Enterprise Resource Planning System (ERP) as shown Table1.

Table1: GP Product-Sales Matrix for Product Type

Product Type	Sales to Customers (Cartons)-Year 2012-2016)					
	2015/2016	2014/2015	2013/2014	2012/2013	Total	Total (%)
Couscous Pasta	574,348	655,424	753,109	76,149	2,059,030	5
Spaghetti Pasta	8,519,107	10,542,614	10,862,939	909,607	30,834,267	75
Short Pasta	2,553,976	2,751,129	2,912,895	229,367	8,447,367	20
Total	11,647,431	13,949,167	14,528,943	1,215,123	41,340,664	`100

(Source: GPC Microsoft Dynamics AX 2012).

In Table 1. ERP records shows that, spaghetti pasta alone accounted for 75% customers sales, followed by short pasta with 20% in sales volume while couscous past came last with remaining 5% in sales volumes form 2012-2016. The demand for spaghetti has also significantly increased from 909,607 cartons in 2012 to 8,519,107 in 2016 as a result higher demands for the products. The records were displayed in bar chart shown in Fig.1 below.

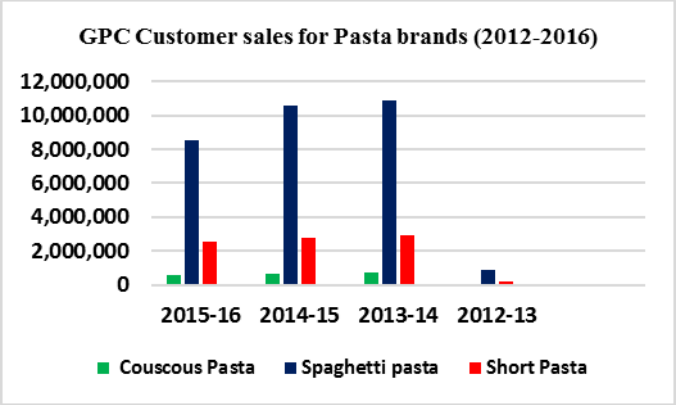

Fig1. GPC Customer Sales for Pasta brands from 2012-2016.

The research paper focused only on spaghetti product since it offered the highest customer value by sales volumes.The next step focused on determination of the pilot line since more than one line produces the same spaghetti product. This is t ensure simplicity and total visualization of the current value streams.

2. Select pilot production line.

The Golden Pasta Company (GPC), has a total of six production lines with the same processing sequences producing the same product family. A thorough analysis of the breakdowns records of all the lines were analyzed. The total numbers of breakdowns were collated from the ERP Service Asset Maintenance (SAM) module to derive the actual breakdown during the same year from 2012 to 2016.

The breakdowns recorded shows that all the six lines, Fava Long Goods 1 (FLG1), Fava Long goods 2(FLG2), Fava Long goods 3 (FLG3), Fava Long Goods 4 (FLG4), Pavan Long goods 1(PLG1) and Pavan Long goods 2 (PLG2) all accounted for increasing breakdowns for the past four years. However, FLG3 only accounted for the highest number of breakdowns both in total and in average. The records were displayed in the table 2. Below..

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Table 2: Production Lines by Number of Breakdowns

Prod. Line	Number of Breakdowns Per Year					
	2015/2016	2014/2015	2013/2014	2012/2013	Total	Average
FLG1	411	356	324	300	1391	347.75
FLG2	443	342	234	235	1254	313.50
FLG3	452	421	339	348	1560	390.00
FLG4	421	404	359	308	1492	373.00
PLG1	432	401	342	234	1409	352.25
PLG2	411	399	321	347	1478	369.50

(Source: Golden Pasta SAM AX 2012).

Total number of Bdn = Xn-3 + Xn-2 +…+Xn);
Where;
X represent number of breakdown
n = year 2015
For FLG3;
Bdn = X2012 +X2013+X2014+X2015
= 348+3339+421+452
Bdn = 1560 breakdowns.
Mean, $\dot{X}$ = $\sum X/n$
= 1560/4
$\dot{X}$ = 390 breakdowns

Final analysis of the sales volumes of the products and number of breakdowns of the production lines enabled the selection of FLG3 as pilot project line for the Value Stream Mapping implementation.

3. Form a cross-functional team

A team of process owners and stakeholders adjudged to have thorough knowledge of the Golden Pasta operations were formulated across all the departments. The Team members includes the shift manager, ERP administrator, operator, warehouse manager, quality control supervisor and the external customer. Besides attending meetings with the team, the external customer key role was to actually define the value form the customer's perspective. They were all trained on the lean methodology, collecting relevance data for value stream, and drawing, lean methods to identify wastes and lean improvement strategies.

4. Collection of relevant data

The mapping team led by the production manager were deployed at this stage. Gemba walk was conducted and joined by all the team members including FLG3 process operators, process supervisor, stripper operator and packers so that a full understanding on the operations and manufacturing processes can be obtained. Details of the manufacturing operations from the start of the raw materials to the final stage of shipping to customers were documented by each team member. Standard stop watch were used to record the cycle time (CT), non-value added cycle time (NVACT), value added cycle time (VACT), waiting time for inventory accumulation (IT). The details in table 3 shows a pre-defined information collected by each team member at every stage of FLG3 manufacturing operations. Data collected from process owners (operators, technicians, warehouse operatives) at shop floor data and ERP data were used to establish the supplier and customers' information. Table below shows th customers' requirements in a month.

Table 3: Customers requirements for FLG3 Production Line

S/N	Customer Requests	ERP Data
1	Customer order	160,000 Cartons (per month)
2	Demand	6400 Cartons (per month)
3	Maximum demand	6660 Cartons (per month)
4	Minimum demand	6321Cartons (per month)
5	One carton of spaghettis	20 sachets (10kg)
6	1 sachet of spaghetti	500g
7	Working period	22 days per month
8	Working hours	22 hours per day
9	Break hours	2 hours per day

(Source: GPC Microsoft Dynamics AX 2012)

Table 4: Total Time Observation Records for Spaghetti Manufacturing processes at FLG3

FLG3 Spaghetti Processes		Time Observation Sheet(minutes)			
Step	Component Task	CT	VACT	NVACT	IT
1	Quality Testing				
2	Charging				
3	Silo cabins				
4	Flour dosing				
5	Mixing				
6	Spreading				
7	Wet scrap				
9	Pre-drying				
0	Drying				
11	Humidifying				
12	Falling Sticks				
13	Cooling				
14	FG cabin				
15	Stripping				
16	Elevators				
17	Packing				
18	Cartonizing				
19	Sorting				
20	Transit inventory				
21	Stacked products				
22	Loading				
23	Weighing				
24	Dispatch				
Total time in minutes					
Production lead time (minutes.)					
Total employees=					

At the end of this project stage, a current state mapping was developed showing details of the processes, material and information flow across the entire value streams.

Details of manufacturing activities responsible for non-valued cycle time constituted the wastes to be eliminated. The current stage map development was completed after 20 days using Microsoft Visio 2016 software.At the end of this stage, the entire team led by the GM/D (Executive sponsor) agreed on six key performance indicator to drive the company objective of meeting customers' requests and reducing cost. The KPIs used to determine the success of VSM methodology in eliminating wastes in pasta manufacturing is depicted in table 5 below.

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Table 5: KPIs for Golden Pasta VSM Implementation.

S/N	Key Performance Indicators (KPI)	Metrics Measurements	Actual value	
			Current	Future
1	PRODUCTIVITY	Production lead time-PLT (Minutes)		
		Cycle Time –CT (Minutes)		
		Overall Equipment Efficiency-OEE		
		Number of breakdowns (Monthly)		
2	DELIVERY	Output produced -O (Cartons)		
		Sales volumes (Cartons)		
3	QUALITY	% Scrap Sold -S		
		Quality demerit index –QDI (Nos)		
		Customer complaints (Nos)		
4	COST	Material cost (Naira/ton)		
		Maintenance cost (Naira/ton)		
		Power (Energy) cost (Naira/ton)		
		Labour cost (Naira/ton)		
5	SAFETY	Loss time Accident-(LTA(Nos)		
6	MORALE	Improvement suggestions (Nos)		
		5S-Housekeeping score (%)		

2.2 Lean Model for waste elimination in Pasta Manaufacturing

A Kaizebn Blitz , a proven lean model was deployed across each stage of FLG3 manuafcturing operations to find out the best techniques that offers the best solution to the identidfied wastes. A Kaizen Blitz is a rapid improvement workshop designed to produce results /approaches to discrete process issues within a few days. It is a way for teams to carry out structured, but creative problem solving techniques in a workshop environment, over a short time scale.

The Kaizen Blitz workshop was a thorough brainstorming session that took place at the Gemba for a a period of 5 days at 8 hours per day.

The current state map was fractionalized into four loops for simplicity with each loop understudied by a group team members respectively. The Loops were created across the entire current state mapping are;

a. customer Loop
b. packaging Loop
c. processing loop
d. supplier loop

Team members were deployed across the entire manufacturing operations, improvement suggestions that actually eliminates the wastes were made in accordance with the seven wastes of lean.

At the end of the workshop, the all the four teams gathered together to evaluate the improvement suggested, and the best techniques that eliminated the identified wastes were adopted and approved.

2.3 Future State Map

After the adopted lean techniques were run along the current state map with identified wastes eliminated, the current Value Stream Mapping (VSM) was remodeled to achieve a future state map.

The following steps were taken to achieve a future state Value Stream Mapping (VSM).

1. Determination of the Takt time

It is fundamental to determine the 'Takt time' for the current production operations of the FLG3 production line before drawing the future state map. Takt time is the rate at which products or services should be produced to meet the rate of customer demand. It is derived from the German word, Taktzeit, which is often referred to as heartbeat or drumbeat of production in lean manufacturing. The value, in conjunction with current production rates, is used to analyze pokes loads, bottlenecks, and excess capacity.

Mathematically,

$$\text{Takt time} = T_a/D\Delta \quad (1)$$

where;

T_a is the available work time/unit of time,

$D\Delta$ is the customer demand rate

On the future state map, the takt time will be noted in the data box'

The Fava Long Goods 3 production operations runs on two shift of 12 hours per day with I hour of break time internal.

In order to calculate the Takt time, the available time and customer demand rate were derived from previous data collected at Gemba.

Available time = (2 shift X 12 hrs.) - (2 hrs. break time)
= 22 hours (2)

Takt time = available time in seconds/customer demand rate
= 22 x 3600 seconds/ 6400 cartons
= 12.375 seconds (3)

2. Futures Steam Mapping implementation steps

The main goal of drawing the future steam map is to build a production chain where each processes would be linked to the external customer(s) either by continuous flow or pull and also ensuring that these processes were close as possible to produce only what the customer(s) only needed. The best way to achieve these steps is to prioritize objectives and goals along the three loops established during the waste identification exercise. The detailed explanation of how it would be implemented on the future map is discussed below.

a. Loop 4: Customer Loop

The objectives to be achieved are

I. Determine the takt time
II. Establish buffer stock to address demand fluctuations
III. Initiate a continuous flow from between stacked FG (finished goods) and loading by replacing the manual loading conveyor with an automatic belt conveyor.

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IV. Only 80000kg of pasta stands should be supplied to the stripper unit from the finished good silos with only 1.3 minutes of inventory time allowed on a continuous flow.
V. Maximum packaging material supplier to the production floor should not exceed 2500 in every 4 hours while the wrapping reels should not exceed 64 reels within the same time period.

The main targets/goals to be achieved at the customer loop are
I. Produce to customers' requests
II. Zero finished goods inventory (except the buffer stock).

b. Loop 3: Packaging Loop

The objectives to be achieved are
I. Initiate a continuous flow from stripping operation to the warehouse entry by installing an automated conveyor belt from packing machines to the warehouse entry point that in order to transfer finished goods directly to the warehouse. This will eliminate cartonizing operation completely and reduce palletizers from 12 employees to zero.
II. Implement kaizen to reduce cycle time from 1567 minutes to 33 minutes.
III. Increase uptime at stripping, elevator and packing processes to 95%.
IV. Establish supermarket pull system between stripping and elevator processes to control excess inventory.
V. Introduce continuous hourly quality control checks on the packed products between packing and the automated belt conveyor and eliminate the 24 hours non-value added time at the transit process.
VI. Eliminate excess packing material inventory at the production floor by using a kaban card every 4 hours to keep material inventory in check between the material supplier and the cartonizing operation.
VII. Establish a FIFO system to prevent over-production and storage of unwanted stock at the warehouse
VIII. Maintain a buffer stock of 1100 cartons of finished goods at the warehouse operation to meet fluctuating customer's demand at peak period.

The main goals/targets to be achieved at the packaging loops are;
I. Only 80000kg of pasta stands should be supplied to the stripper unit from the finished good silos with only 1.3 minutes of inventory time allowed on a continuous flow.
II. Maximum packaging material supplier to the production floor should not exceed 2500 in every 4 hours while the wrapping reels should not exceed 64 reels within the same time period.
III. Zero Scraps.

c. Loop 2: Processing Loop

The objectives to be achieved are
I. Establish continuous flow of material between the flour dosing and mixing.
II. Carry out kaizen to eliminate Work-In- process (WIP) inventory between the spreader the pre-dryer process.
III. Introduce daily production schedules.
IV. Increase uptime from the mixing to the cooler unit to 100%
V. Carry out kaizens to eliminate the root cause of failing sticks at the cooler entrance.

The main goals/targets to be achieved at the processing loops are;
I. Only 4.5 seconds of flour dosing time and 1 minute of mixing time allowed.
II. Zero WIP
III. Zero scraps

d. Loop 1: Supplier loop

The objectives to be achieved are
I. Initiate and sustain a load levelling balance of raw material supplier into the silo bins.
II. Eliminate all quality inspection tests prior to semolina discharge by establishing, quality conformance assurance with Flour mills of Nigeria (FMN) Plc.
III. Eliminate wastes at charging point through the entry of only 100% certified reliability-tested bulk trucks for raw material discharge.
IV. Merge the raw material supply for further processing at the processing loop using a kaban pull system to eliminate excess inventory.
V. Reduce the size of bulk supply of semolina from 30 tons per truck to 20 tons per truck.

The main goals/targets to be achieved at the processing loops are;
I. Only 40 minute of charging time allowed throughout the day on a continuous production
II. Zero WIP at the spreader unit
III. Increase uptime at the flour dosing operation to 100%.

The proposed future state mapping was completed after 15 days using Microsoft Visio 2016 software. The future state map shows the proposed state of the value stream mapping after all the identified wastes would have been removed through the improvements suggestion approved during the kaizen workshop together with some key decisions taken during the drafting of the future state implementation steps.

3. RESULTS

The results obtained from the analysis of data collected at Golden Pasta FLG3 Spaghetti Production line was shown in Table 6. As seen from the table it takes a total of 1 day, 10.4 hours (34.4 hours) to fulfil a customer request while cycle time was 441.08 minutes (7.35 hours)

Now,

Cycle time CT= VACT + NACT

Value Added cycle time, VACT = 252.080 min. (1)

Non Value Added Cycle Tim = 189.000 min. (2)

Therefore,

Total Cycle Time CT = 441.08 min. (3)

The Cycle time was derived from the addition of both value added cycle time and non-value added cycle time as shown in Eq. (3).

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Also,

The inventory Time IT = 1620.30 min. (4)

Production lead time, PLT = CT + IT

= 34.4 hrs. (5)

The Production lead time for the overall current spaghetti manufacturing process was derived from the addition of Eqs. (3) and (4) to arrive at Eq. (5)

% VAT = VACT/ PLT = 252.08/2061.38

= 12.2 % (6)

% NVAT = 100 %- %VAT

= 100 %- 12.2 % = 87.8 % (7)

Table 7 present the proposed data for Golden Pasta Fava Long Goods 3 (FLG3) spaghetti production line after all the identified wastes were eliminated. As seen from the table it takes just 5.04 hours to fulfil a customer request while cycle time was 256.08 minutes (4.27 hours)

Now,

Cycle time CT= VACT + NACT

Value Added cycle time, VACT = 234.08 min. (1)

Non Value Added Cycle Time = 22.000 min. (2)

Therefore,

Total Cycle Time CT = 256.08 min. (3)

The Cycle time was derived from the addition of both value added cycle time and non-value added cycle time as shown in Eq. (3).

Also,

The inventory Time IT = 46.3 min. (4)

Production lead time, PLT = CT + IT

= 302.38 min.

= 5.04 hours (5)

The Production lead time for the future spaghetti manufacturing processes was derived from the addition of Eqs. (3) and (4) to arrive at Eq. (5)

% VAT = VACT/ PLT = 252.08/2061.38

= 12.2 % (6)

% NVAT = 100 %- %VAT

= 100 %- 12.2 % = 87.8 % (7)

Table 6: Current State Total Time Records for Spaghetti Manufacturing processes at FLG3

FLG3 Spaghetti Processes		Time Observation Sheet(minutes)			
Step	Component Task	CT	VACT	NVACT	IT
1	Quality Testing	25	1	24	0
2	Charging	28	5	23	0
3	Silo cabins	0	0	0	60
4	Flour dosing	0.075	0.075	0	0
5	Mixing	7	1	6	0
6	Spreading	10	2	8	0
7	Wet scrap	0	0	0	13.2
9	Pre-drying	60	60	0	0
0	Drying	90	90	0	0
11	Humidifying	35	25	10	0
12	Falling Sticks	0	0	0	56.76
13	Cooling	35	25	10	0
14	FG cabin	0	0	0	1.3
15	Stripping	35	5	30	0
16	Elevators	16	7	9	0
17	Packing	10	5	5	0
18	Cartonizing	30	6	24	0
19	Sorting	30	5	25	0
20	Transit inventory	0	0	0	
					1440
21	Stacked products	0	0	0	53
22	Loading	10	5	5	0
23	Weighing	5	5	0	0
24	Dispatch	15	5	10	0
Total time in minutes		441.08	252.08	189	1620.3
Production lead time (PLT) (minutes.)		2061.38=34.4 hrs. or 1 day, 10.4 hrs.			
Total employees=		43 employees			

The current state map developed for the current pasta manufacturing at FLG3 is shown in Fig.2

Table 6: Future State Total Time Records for Spaghetti Manufacturing processes at FLG3

FLG3 Spaghetti Processes		Time Observation Sheet(minutes)			
Step	Component Task	CT	VACT	NVACT	IT
1	Charging	5	5	0	0
3	Silo cabins	0	0	0	40
4	Flour dosing	1.075	1.075	0	0
6	Spreading	2	2	0	0
9	Pre-drying	60	60	0	0
0	Drying	90	90	0	0
11	Humidifying	25	15	10	0
13	Cooling	35	25	10	0
14	FG cabin	0	0	0	1.3
15	Stripping	5	5	0	0
16	Weighing	7	5	2	0
17	Packing	5	5	0	0
18	Q/C	5	5	0	0
19	Conveyor	5	5	0	0
21	Stacked products	0	0	0	5
22	Loading	5	5	0	0
23	Weighing	5	5	0	0
24	Dispatch	5	5	0	0
Total time in minutes		441.08	252.08	189	1620.3
Production lead time (PLT) (minutes.)		2061.38=34.4 hrs. or 1 day, 10.4 hrs.			

The future state map developed for the future pasta manufacturing at FLG3 is shown in Fig.3

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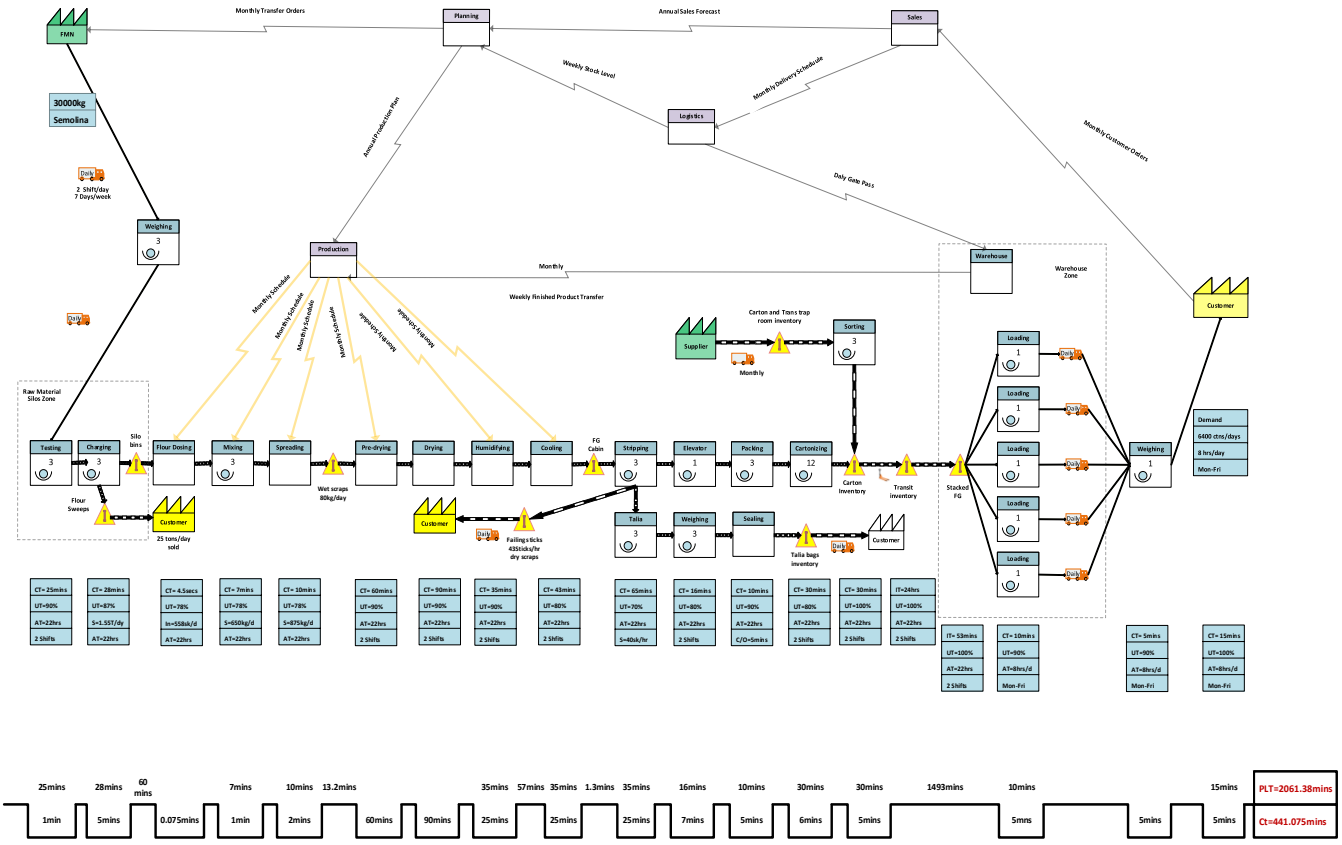

Fig. 2: Completed Current VSM with data boxes and timeline

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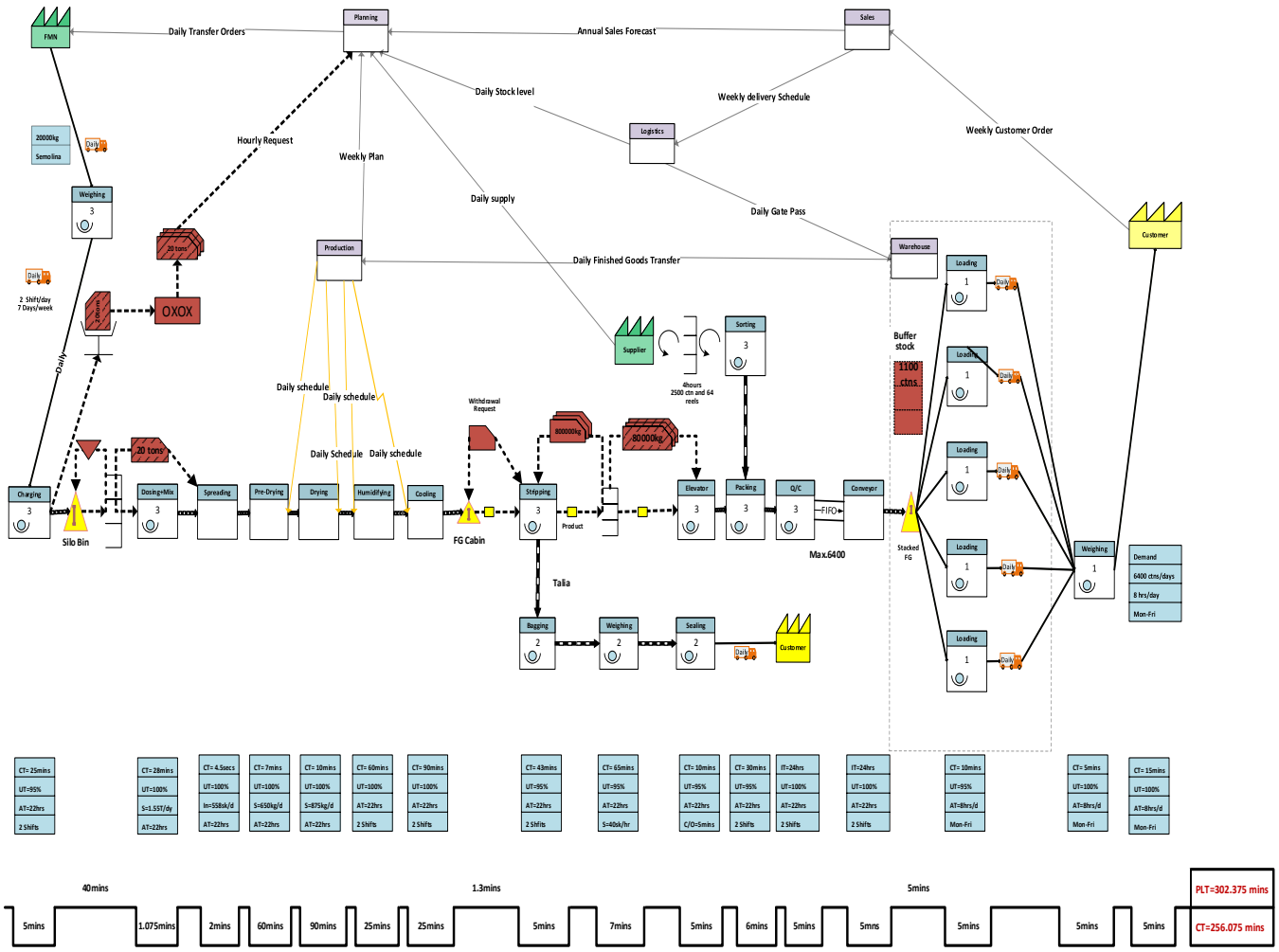

Fig. 3: Proposed Future VSM with data boxes and timeline

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The results of current and future states Key Performance Indicators (KPIs) were used to determine how VSM methodology proved to be a successful tool for waste elimination in pasta manufacturing. These results of the KPIs were presented in the Table 7 below.

Table 7: KPIs for Golden Pasta VSM Implementation.

S/N	Key Performance Indicators (KPI)	Metrics Measurements	Actual value	
			Current	Future
1	PRODUCTIVITY (P)	Production lead time-PLT (Hours)	34.4	5.04
		Cycle Time –CT (Minutes)	441.08	256.08
		Overall Equipment Efficiency-OEE	45%	85%
		Number of breakdown (monthly)	390	10
2	DELIVERY (D)	Output produced -O (Cartons)	10500	7500
		Sales volumes (Cartons)	6400	6450
3	QUALITY (Q)	% Scrap Sold -S	9%	<1%
		Quality demerit index –QDI (Nos)	25	1
		Customer complaints (Nos)	7	1
4	COST (C)	Material cost (Naira/ton)	2050	1020
		Maintenance cost (Naira/ton)	1302	500
		Power (Energy) cost (Naira/ton)	400	350
		Labour cost (Naira/ton)	348	170
5	SAFETY (S)	Loss time Accident-(LTA(Nos)	2	0
6	MORALE (M)	Improvement suggestions (Nos)	5	30
		5S-Housekeeping score (%)	35%	92%

The PDQCSM metrics for both current and future states illustrated in Table 7 clearly achieve the objective of effecting the bottom-line of Golden Pasta Company.

Productivity: Production lead time for FLG£ pasta manufacturing was reduced from 34.4 hrs. to 5.04 hrs., overall equipment efficiency increased from 45% to 85% while number of breakdowns massively reduced from 390 per month to 10 monthly.

Delivery: In terms of delivery, the desired future state is to produce to customer request (64000 cartons) and keep a buffer stock (1100 cartons) at hand to address any changes in customer demand. In current state map, large stock of inventory were wasted and damaged monthly. In the future state, these inventory wastes were eliminated as output were reduced from 10500 cartons per month to 7500 monthly. Sales volume increased from 6400 cartons to 6450 cartons as a result of customer delight in the improved product due to lower cost of production and higher quality.

Quality: Quality demerit index, amount of defective produced produced per hour tremendously reduced from 25 to just 1 while customer complaints ceased completely in the future state.

Cost: Cost is measured in terms of conversion cost of conversion of 1 unit of raw material into final product dispatched to customer. The composition of the conversion cost varies from one company to another. In a typical pasta manufacturing, the flowing costs made up the conversion cost.

I. Material cost : cost of raw material and packaging materials need for production
II. Maintenance cost : Costs of spare parts usage, planned (lubrication, overhauling, preventive and unplanned maintenance (breakdown, corrective and delays due to non-availability o spare parts)
III. Power costs: These includes the cost of electric supply, gas consumption, diesel consumption, compressed air, heat ventilation and air conditioning systems (HVAC) and lighting.
IV. Labour cost; costs savings from labour optimization, elimination of over production that consumed unnecessary man hour lost

Table 8 showed clearly the results comparisons of the various conversion costs performance metrics between the current and future state the conversion cost.

Table 8: Conversion cost for Current and Future State Map

(KPIs)	Metrics Measurements	Actual value		
		Current	Future	Difference
COST	Material cost (Naira/ton)	2050	1020	1030
	Maintenance cost (Naira/ton)	1302	500	802
	Power (Energy) cost (Naira/ton)	400	350	50
	Labour cost (Naira/ton)	348	170	178
Total conversion cost savings Naira/ton				2060

(Source: Balanced Statement of Accounts for October, 2016)

This means that total value of conversion cost savings was expected to generate at 2060 naira per ton
In a day 6400 cartons of pasta are demanded in average.

1 Carton = 500g x 20 pieces = 10000g
= 10kg or 0.01 ton (1)

Therefore,
6400 cartons = 0,01x6400 tons
= 64 tons of pasta (2)

But,
I ton is equivalent to 2060 naira in conversion cost

Finally,
64 tons = 2060 x 64 naira will yield
= 131, 840 naira /day (3)

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Golden Pasta runs and make sales of pasta in 320 days excluding holidays and planned maintenance (Sales Report March, 2016 AX 2012).
The expected cost savings in a year will amounted to;
Cost Savings (yearly) = 131, 840x 320
= N 42, 188,800 (4)

4. DISCUSSION

The current state value stream, mapping shown in Fig.2. clearly revealed that Fava Long Goods 3 (FLG3) spaghetti production line has an extremely long Production lead Time (PLT) of 34.4 hours (1.43 days) compared to cycle time of 7.35 hours. This signifies that it takes a unit material 1.43 days to pass through the entire FLG3 production line to before it turns to a finished good. The extremely long production time was as a result of over processing (quality tests), scraps produced during charging of raw material, waiting time in the mixing, spreading, humidifying, cooling , stripping, elevator, cartonizing, transit area, and weighing processes , over production at FG cabins,, stripping, talia operations, stacked finished goods at the shop floor and warehouse, unnecessary motion during quality tests, spreading, cartonizing by palletizers,, high accumulation of inventory time at charging, silo bins, spreading, cartonizing, transit area, and stacked products at warehouse, transportation time at the transit area and loading operation in the warehouse and finally several defect time consumed throughout the entire production line caused by breakdowns and quality issues.
It was also observed that Golden pasta Company are currently not producing in accordance with customers' requirements but according to the availability of raw materials which eventually resulted to producing unwanted finished products not desired by the customers.
The future state value stream, mapping shown in Fig.3. clearly revealed that Fava Long Goods 3 spaghetti production line Production lead Time (PLT) of 5.04 hours with 77.4% of value added time (VAT) has proved that FLG3 production line can be greatly improved if the proposed future state map is properly implemented. The large improvement in the future state map is a direct reflections of the elimination of non-value added activities along the spaghetti manufacturing process. The raw material supply has been improved to daily requests with an introduction of load balancing system of 4 trucks every 40 minutes to meet customer demand. A kanban post and signal system put was place to cushion production at the upstream section, which directly improved the effectiveness and efficiency of the production process. The visual inspection and quality test conducted during raw material discharge were considered as wastes since there have not been quality issues for the past three years from Flour Mill of Nigeria suppliers. A quality conformance certificate put in place eradicated these quality issues as only certified trucks with test certificated would be allowed for supply.

The inventory accumulation and scraps generated by faulty bulk trucks was considered a waste because only reliability-certified trucks would only be allowed into the premises for raw material supply.
The supermarket pull system introduced at the stripper and packing units will greatly improve the efficiency of the system between the upstream processing loop and downstream packaging loop because it will generate the expected continuous flow process that will eliminate all bottlenecks along the entire spaghetti manufacturing processes.
The 24 hours non-valued added time was eliminated with the installation of an automated conveyor belt system directly from packing machine terminal to the warehouse as agreed and test run by the management during the kaizen blitz workshop..
The cost savings of N42, 88, 880 realized from the conversion cost loss matrix approved by the financial director would help the Golden Pasta expand their production capacity and continue to generate a large income base yearly for the foreseeable future.

5. CONCLUSION

This work demonstrated the use of value stream mapping techniques, a lean manufacturing principles for the elimination of wastes along pasta manufacturing company in Nigeria as revealed in this case study. The following conclusions can be drawn from this work:

I. The current state mapping of the Fava long goods 3 (FLG3) production line was developed after the pasta manufacturing operations were investigated, relevant data collected and the value-added and non-valued added time analysed.
II. A lean model, Kaizen blitz was adopted to eliminate the wastes. Continuous improvements techniques were applied on the current state map to eliminate the identified wastes.
III. A future state map was finally remodelled after the wastes were eliminated with key performance indicators showing clearly how the value stream mapping effected the bottom line with associated cost benefits for the lean implementation.
IV. It was also revealed that value stream mapping was a proven effective tool in eliminating wastes due to the reduction of extremely long production lead time of 34.4 hours (1.43days) to just 5.04 hours on a single Spaghetti production line. This revealed that 85.3 % of the current manufacturing time were mere wastes that can be eliminated.
V. It was also revealed that value stream mapping techniques is a successful tool in elimination al the seven tenets of lean wastes such as over-production, inventory time, waiting time, transportation, unnecessary motion, over-processing and defects as pointed out in the work.
VI. The potential cost savings of N42, 188,880 (yearly) revealed by the balanced sheet as approved by the finance director means that Golden Pasta spaghetti production line can be made more profitable in the future.
VII. Apart from the reduction of production lead time, other benefits from value stream mapping include, increase in overall equipment efficiency (OEE), improved outputs, higher sales volumes, reduction of scraps, massive reduction in customer' complaints, reduction in occupational accidents and improved moral which are key indicators for the success and sustenance of the Golden Pasta team from Top management to the last man in the shop floor. The involvement and co-operation of top management and the shop floor team have been the corner-piece to the success of this work.

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